

# ORANGES Evaluation Test Plans

Test Plans for the US DOT sponsored  
Evaluation of the ORANGES Electronic  
Payment Systems Field Operational Test

(Revision 2)

US DOT/Volpe National  
Transportation Systems Center

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## Foreword

This document is one of a series of working papers that report on progress for the US DOT evaluation for Phase I of the ORANGES field operational test. Each working paper corresponds to a Phase I task. At the conclusion of Phase I, these documents will be updated and compiled to form a final report. Phase I documents include:

- Evaluation Strategy and Plan – issued November 6, 2001
- **Test Plans – this document**
- Statistical Analysis of “Before” Data
- Risk Assessment

The test plans reflect the current design and plans for ORANGES implementation, as of the date of this document. The design could still vary prior to or during implementation. The evaluation goals and measures have changed from those originally presented in the Evaluation Strategy and Plan document.

The FOT partners believe the limited scale of anticipated deployment could limit noticeable changes in the evaluation measures. The evaluation team has addressed this issue in developing test plans (e.g., by focusing data collection on the specific equipment and riders to be involved in the limited scale deployment). This is nonetheless acknowledged as a legitimate issue for the context to interpreting the data analysis.

Revisions to this document update the details of the planned implementation – and incorporate the effects on the goals, measures and test plans – to reflect changes that have been introduced by the implementing agencies since the original final draft of this document was released on September 4, 2002.

Revision 1 (released November 5, 2002) includes:

- LYNX has discontinued the routes (“links”) that were to originally be equipped to accept the ORANGES card, so alternative routes have been introduced.
- The Parking Bureau was not able to make suitable arrangements with the vendor of their parking meters to incorporate ORANGES card acceptance at parking meters.
- OCEA has decided to add direct use of the ORANGES card with in-lane validators, to the already intended use of smart card accepting transponders.

Revision 2 (released January 20, 2003) includes:

- Additional information about the card issuance and revaluing infrastructure.
- A change in the Goal 8 discussion, based on the Parking Bureau decision to not support the automatic renewal of monthly parking permits through the ORANGES system.

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## 1 Introduction

This report describes each test plan developed for the USDOT evaluation. Each test plan identifies data collection details (i.e., why, what, how, where, when and by whom). The report also discusses how the collected data will be analyzed. The test plan details were discussed with staff at the participating agencies.

There is a separate test plan for each evaluation goal. The goals were developed by consensus with the project partners. Goals and measures have changed since the initial consensus to reflect the design evolution. Two types of evaluation goals have been identified – quantitative goals and qualitative goals. Quantitative goals use a numerical measure and initial test hypothesis. Qualitative goals explore user perceptions and do not involve an initial test hypothesis.

For each evaluation goal, the test plan identifies the:

- Evaluation measures
- Test hypothesis (when applicable)
- Modes involved (i.e., between parking, tolls and transit)
- Types of data comparisons (i.e., before only, before/after, control/test, test only)
- Data needed
- Data collection methods (by the participating agencies, to provide data to the evaluation)
- Data analysis methods (by the USDOT evaluation team)

## 2 Background Description of the ORANGES Field Operational Test System

The FOT will implement a central stored value system – using a clearinghouse system to be operated by Touch Technology Inc. (TTI). Payment transactions with smart card readers operated by individual agencies will be transmitted to the ORANGES clearinghouse for reimbursement. The long-term ORANGES plan involves Central Florida residents and tourists using the prepaid accounts for many purposes.

The FOT is expected to involve a limited deployment:

- Card base: The agencies plan to maintain 800-1200 smart cards in active use at all times during the test.
- Transit deployment: LYNX will equip Links 13 and 15, which both connect post-secondary educational institutions with the downtown area.
- Toll deployment: OOCEA will equip select lanes of the Holland East toll plaza to accept the Etkon transponder with a smart card as well as install smart card accepting validators in select manual lanes.

- **Parking deployment:** City parking will equip the Central Boulevard, Library and Market Street garages.
- **Revaluing facilities:** Each agency will offer facilities for smart card issuance and revaluing. This includes points of sale at agency-operated customer service facilities as well as at selected attended toll lanes. Passes will continue to be sold only through LYNX facilities and transponders will continue to be only available through OOCEA facilities.

## OOCEA

Rather than integrate the existing E-PASS Electronic Toll Collection (ETC) system with the smart card clearinghouse, the ORANGES partners have opted to create a parallel ETC system in equipped lanes, using Efkon smart card accepting transponders (see Figure 1) and smart card validators.

**Figure 1:**  
Transponder that  
Accepts Smart  
Cards



Source: Efkon

### *Smart Card Accepting Transponders*

The OOCEA customer service center will distribute the Efkon smart card accepting transponders in addition to conventional transponders. Customers will insert the smart card into the Efkon transponder slot to have their toll deducted from their ORANGES account. Efkon transponders use infrared communications with the laneside readers. Readers will be integrated with the clearinghouse, bypassing the existing ETC system. OOCEA customers receiving an Efkon transponder for use with the equipped toll plaza lanes will continue to use their conventional transponder for non-equipped toll lanes.

### *Smart Card Validators*

Select manual lanes will also be equipped with validators, similar to those that will be used for payments at parking garages and LYNX buses. The validators will allow customers with an ORANGES smart card to pay tolls by stopping and placing the smart card in proximity to the validator mounted in the lane. In contrast to the validators being used for parking and transit, Efkon will supply these validators. The validators and point of sale devices will connect with the ORANGES clearinghouse.

## LYNX

All buses have registering fareboxes, which LYNX recently replaced with a new model. Rather than purchase new fareboxes with an integrated smart card reader, with only certain smart cards supported by the vendor, the ORANGES partners opted for stand-alone validators from Ascom Transport Revenue Systems (see Figure 2). These will be mounted beside the fareboxes but not integrated with them.

**Figure 2: Stand-Alone  
Smart Card Validator**



Source: Ascom

### City of Orlando Parking Bureau

Selected garages will accept the ORANGES card using a validator. The ORANGES card will be an alternative to both cash and the existing radio frequency “proximity” access cards used as monthly passes. The transaction data will be transferred to the ORANGES clearinghouse after being consolidated by the Parking revenue management system.

### Smart Card Issuance and Revaluing

Cards will be initialized centrally and initially distributed to the cardholders by mail. Cardholders would use one of the revaluing points to add a balance or a LYNX pass to the card. Replacement cards will still be initialized centrally and then distributed either by mail or through one of the revaluing locations.

- The following provide specific details on the revaluing infrastructure for each agency :
  - City of Orlando Parking Bureau: The Parking Bureau will offer a total of 5 attended point of sale locations for card revaluing. Cash revaluing will be offered at one point of sale in each of the Market and Library Garage booths. At the Central Boulevard Garage, there will be three points of sale (one in the booth and two in the office). Each point of sale at the Central Boulevard Garage will support cash, debit card and credit card revaluing.
  - LYNX: LYNX will offer a total of 5 attended point of sale locations for card revaluing: LYNX downtown transfer center, LYNX administrative building, campuses of the University of Central Florida (UCF) and Valencia Community College, and the Colonial Plaza Mall.
  - Orlando-Orange County Expressway Authority (OOCEA): OOCEA will offer a total of 5 attended point of sale locations for card revaluing: at the East and West Customer Service Centers, OOCEA administrative building, one attended cashier booth in each direction at the Holland East plaza.

Cardholders will be able to add value to their stored value account by making a remote or in-person payment at any of these centers. Each of these facilities will allow revaluing in exchange for any form of payment normally accepted. The stored value account will be available for payment with any of the participating agencies. Payment methods associated exclusively with a single agency will only be supported by that agency’s customer service facilities (e.g., Parking Bureau for monthly parking permits, LYNX for transit passes).

## 3 Test Plans for Quantitative Goals

This set of evaluation goals involves numerical measures and initial test hypotheses. In assessing any changes observed, it will be important to consider the limited scale of deployment. Many of the quantitative goals and measures involve potential changes in payment behavior (e.g., using a new payment method, willingness to make prepayments). Such changes in behavior might increase with a more comprehensive deployment and after the system has been in place longer.

### **3.1 Quantitative Goal 1 – Gather Clearinghouse Performance Measures**

The clearinghouse operator will provide measures that characterize the clearinghouse operational performance (e.g., processing time required for transaction batches, communications error rates) as well as identify the specific measures. There is no test hypothesis for this goal. During after testing, the evaluators will complete a statistical assessment.

### **3.2 Quantitative Goal 2 – Gather System Acceptance Test Results**

The program manager will provide results from acceptance testing completed before the system is brought into revenue service. There is no specific measure or test hypothesis, but the acceptance testing results will provide an important baseline for the operational characteristics of the system.

### **3.3 Quantitative Goal 3 – Demonstrate Reliable Performance for Smart Card Accepting Transponders**

The Eikon smart card accepting transponder is unproven in North America, and uses an infrared interface (also unproven in North America). The goal is to demonstrate reliable equipment operation during the operational test that does not interfere with customer reaction to the ORANGES card.

#### **Measure**

- Difference between the numbers of monthly transactions for smart card accepting and conventional transponders.

#### **Test Hypothesis**

- Using a smart card accepting transponder instead of a conventional transponder will not reduce the number of transponder-based transactions.

If there were significant operational problems with the smart card accepting transponder or the interface, customers might divert some transactions to cash. The Eikon equipment is established in Europe and Asia, but this must be established for the FOT.

#### **Modes Involved**

- Toll

#### **Types of Data Comparisons**

- Test and control

The test will measure the average number of monthly transponder transactions by smart card transponder users. The control test will measure the average number of monthly

transponder transactions by conventional transponder users. These monthly totals will be examined throughout the operational test period for any reductions in use over time. Reductions for the smart card accepting transponders that reflect similar reductions in use of conventional transponders would still support the test hypothesis.

#### Data Needed

- Average number of monthly transactions for a group of smart card accepting transponders and a comparable group of conventional transponders.

#### Data Collection Methods

The clearinghouse will provide the number of toll transactions for smart card transponders. The existing E-Pass ETC system must provide the number of transactions completed by selected conventional transponders. Transponders of both types must have comparable travel patterns (e.g., commuters who average two toll transactions per weekday).

### **3.4 Quantitative Goal 4 – Reduce Transaction Times**

Reducing average transaction times is important for all three modes and could translate directly into reduced queuing and bus dwell times. This quantitative goal does not apply to tolls, since the percentage paying by transponder or smart card will not noticeably increase within the high volume of daily plaza transactions.

#### Measure

- Average payment transaction duration, for each mode and type of equipment.

#### Test Hypothesis

- Prepaid payment transactions will be quicker than cash payment, so the average duration will decrease if the % prepaid increases.

#### Modes Involved

- Parking garages
- Transit

#### Types of Data Comparisons

- Before and after

#### Data Needed

- For each equipped parking garage exit or bus
  - Average transaction duration

### Data Collection Methods

The basic approach for each equipped device will be to measure throughput with continuous demand. Average transaction time is the inverse of throughput.

The transit method will use the LYNX Automatic Passenger Counters (APC) vehicles. APC counts passengers that board and alight at each stop, and bus dwell time. Dwell time divided by the number boarding will provide the average transaction time for that stop. LYNX will identify any stops where alighting volume governs dwell time (i.e., which would cause high average transaction times).

For parking garages, transaction records for the cashier station plus those for the validators from the clearinghouse will provide the total. If the Parking Bureau cannot identify periods of continuous demand without field observation, it may be easiest for their staff to visually count the transactions.

### **3.5 Quantitative Goal 5 – Increase Prepaid Revenue Share**

The agencies wish to (1) reduce cash handling costs and (2) increase the “float” investment revenue earned from holding prepaid revenue. However, changes in cash handling costs and float revenue are not expected due to the limited scale of deployment. Prepaid revenue share was selected as a surrogate quantitative goal that may be measurable for equipped facilities. It is necessary to determine whether some of the ORANGES card usage is displaced from other prepaid payment methods rather than from cash. This goal does not apply to tolls, since the percentage paying by transponder will not noticeably increase within the high volume of daily plaza transactions.

#### Measure

- % of transactions that use a prepaid revenue payment method

#### Test Hypothesis

- % prepaid transactions will increase for equipment accepting the ORANGES card.

#### Modes Involved

- Parking
- Transit

#### Types of Data Comparisons

- Before and after.

#### Data Needed

- For each payment device equipped for smart card acceptance
  - % transactions paid with cash
  - % transactions paid with the ORANGES card

- % transactions paid with other non-cash methods

#### Data Collection Methods

Each agency will gather data from its revenue systems. These systems include the transaction data from parking garages, the revenue systems at LYNX garages and clearinghouse data.

### **3.6 Quantitative Goal 6 – Increase Automated Payment Equipment Uptime**

Cash accepting equipment can suffer more downtime as the cash volume increases. This applies more to automated devices than to attended locations. By displacing cash use, the ORANGES card should reduce downtime. This would reduce maintenance costs and revenue loss (i.e., at unattended devices where revenue cannot be collected while the device is down).

#### Measure

- % operating hours with cash processing available (coins for toll machines; coins and bills for fareboxes)

#### Test Hypothesis

- The frequency and severity of planned and unplanned maintenance for unattended devices relates to the cash processed. Cash processing availability should increase as % prepaid increases.

#### Modes Involved

- Tolls – for automatic coin machines
- Transit – for fareboxes

#### Types of Data Comparisons

- Before and after

#### Data Needed

- For each equipped and control device
  - Daily cash revenue
  - % of operating hours each day with cash processing available

“Daily cash revenue” and the data collected for Goal 6 (i.e., % paid by cash, ORANGES card and other non-cash methods) will be used to take into account any differences in the level of cash acceptance between the before and after – and test and control – availability data.

### Data Collection Methods

Data will be gathered by agencies from maintenance records.

LYNX maintenance tracks each incident and whether the cash processing is taken out of revenue service. They will provide the average number of failures per month and the duration out of revenue service.

OOCEA data may be more limited. Coin machines are maintained under a fixed price contract and the actual maintenance may not be available. The ETC system data indicates when each lane was out of service, but this may not indicate whether an outage is due to a coin machine failure.

If needed due to variations in repair frequency and severity, before and after data collection should be completed in the same season.

### ***3.7 Quantitative Goal 7 – Cardholders Use the Joint Account***

Agencies hope ORANGES cards are used to travel between modes and store high prepayments. This quantitative goal measures how and where cards are used (i.e., rather than the effects of the card use, with other quantitative goals).

#### Measures

- Cumulative probability distributions for transaction frequency, over the cardholders population, segregated between payment and revaluing transactions as well as by mode
- Cumulative probability distributions for transaction value, over the transactions population, segregated between payment and revaluing transactions as well as by mode
- Average stored value balance, for each card, segregated on the basis of card use frequency
- Percentage breakdown of the cardholder population, between cards used for one mode, for mode pairs or for all three modes.

#### Test Hypothesis

- Most cardholders will maintain a prepaid balance and use the card regularly. Some may use the card alternately for transit and tolls, some for downtown parking and toll payment. Use for transit and parking is not expected to be common for this operational test because the selected transit routes do not serve park and ride facilities.

#### Modes Involved

- Parking
- Tolls
- Transit.

### Types of Data Comparisons

- Test only

These measures involve the specifics for card use, so there are no before or control tests.

### Data Needed

- Individual transaction values and dates, by cardholder, for each payment and revaluing device
- The stored value balance after each transaction

### Data Collection Methods

The clearinghouse will gather the data from their transaction and balance databases.

## **3.8 Quantitative Goal 8 – Characterize Current Pass Distribution and Permit Billing Costs**

LYNX uses prepaid fares extensively, issuing paper and magnetic stripe passes distributed through four sales outlets and by mail order. For the FOT, LYNX passes will be renewed directly on the smart card at sales outlets or revaluing locations. Sales locations will need fewer paper passes, which should provide savings.

The ORANGES card can also replace the monthly “proximity” permit for garage parking. Permit holders are billed monthly. Although not provided in the initial deployment, a permit could be automatically renewed and billed to a pre-registered credit card.

However, any reduction in passes distributed will be limited during the test (and permits will still be billed using conventional methods). Characterizing current costs for pass distribution and permit billing will indicate potential cost savings if future deployment achieves bigger reductions.

This does not apply for tolls, which already use a transponder and autoload.

### Measure

- Costs for distributing (e.g., procurement, inventory, delivery and commissions) conventional weekly and monthly passes.
- Costs for monthly billing of garage permits.

### Test Hypothesis

- None. The limited test scale is not expected to have much impact on these costs.

### Modes Involved

- Transit
- Parking garages

### Types of Data Comparisons

- Before only

### Data Needed

- Number of weekly and monthly passes distributed per month.
- Number of garage “proximity” permits billed per month.
- Monthly cost for distributing passes. Detail the specific cost categories included.
- Monthly cost for billing garage permits. Detail the specific cost categories included.

### Data Collection Methods

LYNX will provide monthly costs for distributing passes to sales outlets. City Parking will provide monthly costs for billing garage permits. This will include the types of costs to assist in interpreting the findings.

## ***3.9 Quantitative Goal 9 – Characterize Current Processing Cost per Cash Transaction***

ORANGES cards should decrease cash processing costs for transit, parking and tolls. However, many types of cash processing savings may not be achieved until card use is widespread. The limited use of smart cards in the test may not achieve a cost savings in this area.

Characterizing current cash processing costs will indicate potential cost savings if future deployment achieves bigger reductions.

### Measure

- Costs for processing cash, for each mode.

### Test Hypothesis

- None. The limited test scale is not expected to have much impact on these costs.

### Modes Involved

- Transit
- Tolls
- Parking garages

### Types of Data Comparisons

- Before only

### Data Needed

- Monthly costs for processing cash, by mode.
- Dollar value of cash processed monthly, by mode.

### Data Collection Methods

Each agency will provide the monthly cost for cash processing. This will include the types of costs to assist in interpreting the findings.

## 4 Data Analysis for Quantitative Goals

Some measures will not need statistical analysis, providing complete information that characterizes the system before or after implementation. Data of this type includes:

- System acceptance test results
- The values, quantities and mode types of individual card transactions, including the stored value balance after each transaction
- Pass distribution, permit billing and cash processing costs

Many measures will involve only a sample. Data of this type includes:

- Clearinghouse performance measures
- Number of monthly toll transactions
- Daily revenue
- % revenue using a certain payment method
- Duration for a set of transactions
- % of operating hours cash processing is available

Statistical analysis will be performed on samples. This is important because uncontrollable factors cause measures to vary. For example, duration for a set of boarding transactions will vary with differences due to factors such as how long people take to pay with cash or whether the driver is asked for directions.

First, the average and standard deviation will be calculated. Using the standard deviation (a measure of how widely dispersed are the sample observations) and the sample size, a statistical inference statement will be developed. This would be of the form, "With a 95% level of confidence, the overall population average for this sample is expected to lie within the following range around the sample average".

This expected range is known as the confidence interval, and can be expressed as a precision percentage. For example, a range from 75 to 125 around an average of 100 can be expressed as +/- 25% precision. The statistical relationship for the precision percentage can be expressed with the following formula:

- $P = ((1.96 * \sigma) / \sqrt{N}) / X$

Where:

P = Precision percentage

X = Average

$\sigma$  = Standard Deviation

N = Sample Size

Although a precision percentage of 25% has been selected, sample size cannot be selected in advance because the average and standard deviation are not known. Agencies will provide initial samples with at least 50 observations. The precision percentage will be calculated for each sample. If it is higher than 25%, an additional sample will be requested. There may be practical limits on the maximum sample sizes agencies can support.

## 5 Test Plans for Qualitative Goals

The qualitative goals use discussion groups – focusing on the perceptions of various user categories. Discussion groups are exploratory, so test hypotheses were not developed. Hypotheses may be identified based on before data, depending on the views expressed.

### 5.1 Qualitative Goals 10 to 13 – Understand Perceptions of System Users (By User Category)

#### Measure

- Evolution of user perceptions expressed in discussion groups.

#### Modes Involved

- Parking
- Tolls
- Transit

#### Types of Data Comparisons

- Before and after

Discussion group participants should be users of the test system.

#### Data Needed

- Customers
  - General benefits

- Ease of use
- Convenience of revaluing
- Operations and maintenance staff
  - General benefits
  - Reduced payment disputes
  - Reduced transfer abuse
  - Ease of customer use
  - Maintenance
  - Training
- Planning and management staff
  - General benefits
  - More comprehensive data collection
- Partners
  - General institutional issues
  - Inter-partner collaboration issues

#### Data Collection Methods

The ORANGES implementation team will assist in recruiting participants and provide a facility for discussion groups. The evaluation team will script, moderate and document the discussion groups. The number of participants is limited to 10-15 people. This size restriction is high enough for group dynamics to help stimulate discussion, but low enough that the facilitator can still moderate the group and ensure that all participants provide opinions.

For selecting the cardholder group the following collaborative process is proposed:

- The implementation team will gather pre-screening information during enrollment.
- The US DOT evaluation team will review cardholder characteristics, and cluster them into recruitment subgroups (i.e., recruit 2 from group 1, 2 from group 2, etc.).
- The implementation team will use these subgroups to recruit participants and arrange logistics (e.g., facility, refreshments, incentive payment as they exit). The evaluation team will also play a direct role in helping the implementation team with these arrangements, to help ensure its goals are met.

The customer discussion group should be diverse and representative for criteria similar to:

- Gender and age
- Zipcode

- Approximate number of times equipped transit services, toll booths and parking meters are used per month
- Use a computer regularly (i.e., surrogate to general familiarity and comfort level with advanced technology)?
- Use a credit or debit card regularly?

Recruited cardholders will be taken through a structured group discussion that draws out their perceptions about key aspects of the program. There will be a discussion group at the beginning of the program and another later once the program is in place for several months. Cardholders must be selected before the group can be recruited, so the “before” group may occur after revenue service begins (the initial discussion would represent perceptions with their early card use).

Staff group participants will be selected by agencies prior to implementation. There will be two groups – operations/maintenance and management/planning. Discussion topics will be geared to identifying and exploring their perceptions about the system. For each, there will be discussions before and after implementation.

Top management representatives of the agencies and private sector hold regular meetings regarding project status. Although the evaluators do not participate in these meetings, they will be provided with the minutes. In addition, an outside facilitator is conducting ongoing partnership building discussions – evaluators will receive the notes. Some of the management representatives are participating in the evaluation team meetings, during which collaboration perceptions are discussed.

## 6 Next Steps

### 6.1 Rest of Phase I (Includes Before Data Collection)

Before data collection must be completed prior to – but not too far in advance of – field implementation, involving the specific equipment and individuals that will use the system. Initial statistical analysis will be completed soon after collection. The evaluation team will also consider strategies for addressing – prior to FOT implementation – any issues threatening the potential success of the FOT or evaluation.

The following table summarizes the required before data collection:

	Facility Type			
	Clearinghouse	Buses	Garages	Toll Lanes
<b>Quantitative Goals</b>				
<b>Goal 1 – Clearinghouse Performance Measures</b>				
<b>Goal 2 – Acceptance Test Results</b>				
<b>Goal 3 – Demonstrate Performance for New Transponders</b>				
<b>Goal 4 – Transaction Times</b>		✓	✓	

<b>Goal 5 – Prepaid Revenue Share</b>		✓	✓	
<b>Goal 6 – Automated Equipment Uptime</b>		✓		✓
<b>Goal 7 – Joint Account Use</b>				
<b>Goal 8 – Current Pass Distribution and Permit Billing Costs</b>		✓	✓	
<b>Goal 9 – Current Processing Cost per Cash Transaction</b>		✓	✓	✓

## 6.2 Subsequent Phases (Includes After Data Collection)

After testing should occur a few months after implementation, when users are accustomed to using the system. Control tests will be conducted at around the same time as the corresponding after tests. Initial statistical analysis of after and control data will be completed soon after collection. Once data collection and analysis is complete, results will be interpreted and presented in the final report.

The following table summarizes the required after data collection:

	Facility Type			
	Clearinghouse	Buses	Garages	Toll Lanes
<b>Quantitative Goals</b>				
<b>Goal 1 – Clearinghouse Performance Measures</b>	✓			
<b>Goal 2 – Acceptance Test Results</b>	✓	✓	✓	✓
<b>Goal 3 – Demonstrate Performance for New Transponders</b>				✓
<b>Goal 4 – Transaction Times</b>		✓	✓	
<b>Goal 5 – Prepaid Revenue Share</b>		✓	✓	
<b>Goal 6 – Automated Equipment Uptime</b>		✓		✓
<b>Goal 7 – Joint Account Use</b>	✓			
<b>Goal 8 – Current Pass Distribution and Permit Billing Costs</b>				
<b>Goal 9 – Current Processing Cost per Cash Transaction</b>				